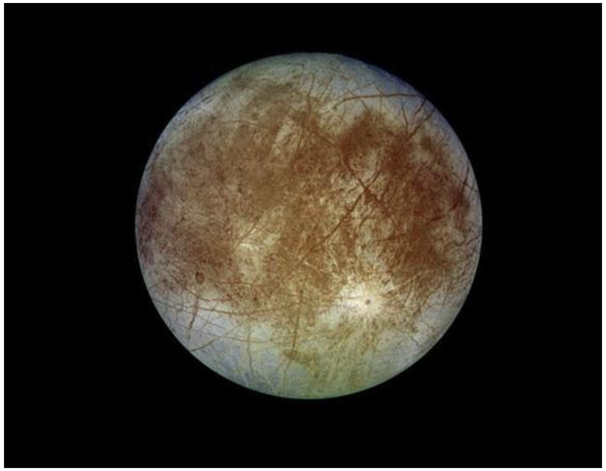
Magnesium Diboride (MgB2)-Based Bolometer Array for Far IR Thermal Imaging and Fourier Transform Spectroscopy Applications

Rationale:

- **Need for more sensitive detectors:**
  - **Thermal mapping of cold planetary bodies**
  - **Study of atmospheric molecular species using Fourier Transform Spectrometer (FTS) applications.**
  - **Outer planets and icy satellites missions**
  - **Future Uranus, Neptune, Titan missions**



Europa

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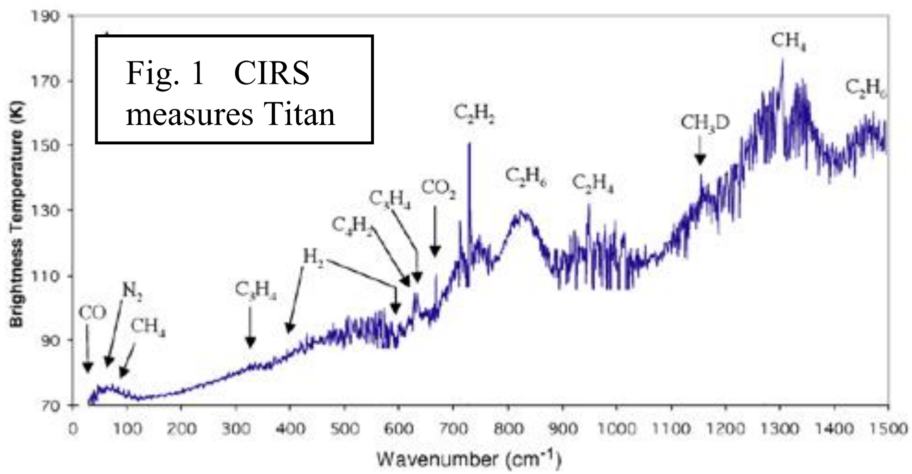
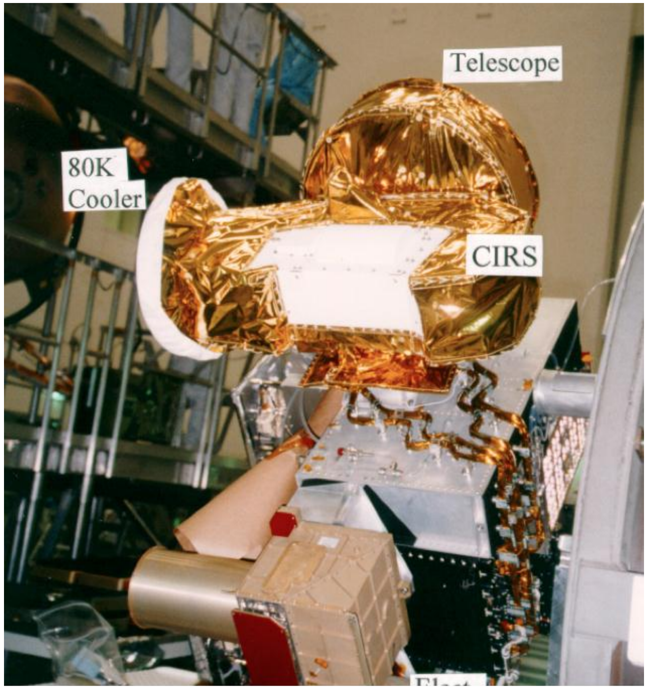
FTS: Improvement in the long wavelength portion of the spectrum





CIRS/Cassini instrument

- Single pixels ---FTS
- Linear array ---Push broom configuration/ thermal mapping
- 2-D array--- Far-IR camera

What is available for far–IR investigation

- **CIRS/Cassini:**
  - **FIR focal plane**
  - **Two single BiTe thermal detectors (thermopiles) operating at 170 K;**
  - **Each detector with a specific detectivity, D* ~ 3x 10^{9} $cmHz^{1/2}/W$ near the low frequency end of a 0.4-to-30 Hz band pass.**

- **Commercially available pyroelectrics have a D* ~ $7x10^{8}$ $cmHz^{1/2}/W$ and operate at 300K**

- **YBCuO has good sensitivity ~ $1x10^{10}$ $cmHz^{1/2}/W$**
  -But grows only on R-plane sapphire, LaAlO3..
  -Difficult to architecture
  - Time constant ≥ 100 ms

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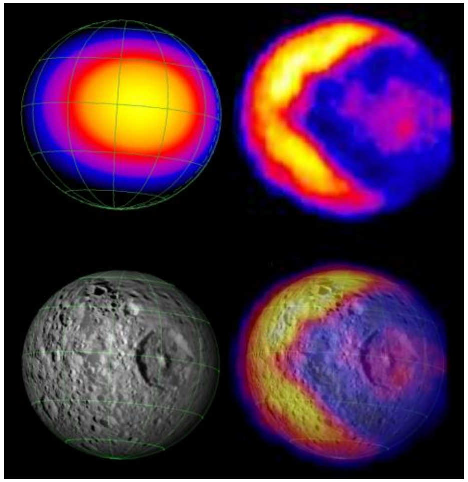
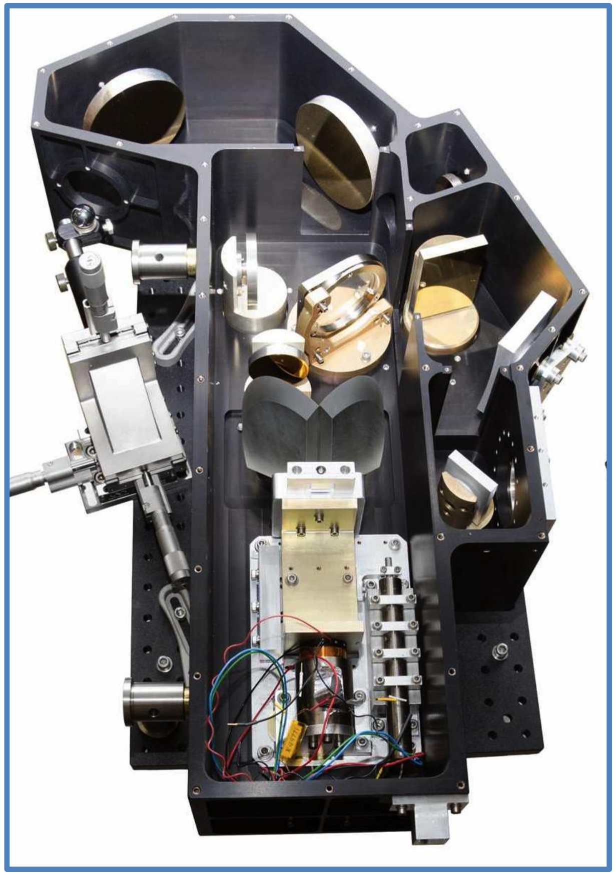
Mimas



- **New smaller FTS under development (J. Brasunas is PI)**
- **Less than ½ the mass of CIRS/Cassini**
- **Baselines high Tc superconduting thermal detector at far-IR focal plane**
  - **Magnesium diboride (MgB2)**
  - **Yitrium Barium Copper Oxide (YBCuO)**

Parameter	CIRS	CIRS-*lite*
band-pass (μm)	7 to 1000	7 to 333
resolution (cm^{-1}) apodized	0.5	0.125
telescope diameter (cm)	50	15
detectors	HgCdTe thermopile	HgCdTe high Tc
detector temperature (K) optics temperature (K)	75 and 170 170	75 and 89 ~150
point-able mirror	no	TBD 1 kg
footprint (km @ 250 km)	1 & 0.05	1 & 0.4
mass (kg)	43	15 to 20

Brasunas et al.

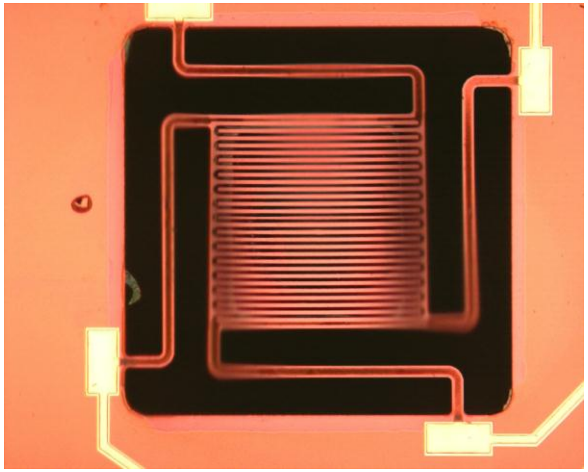


Cirs-*Lite*

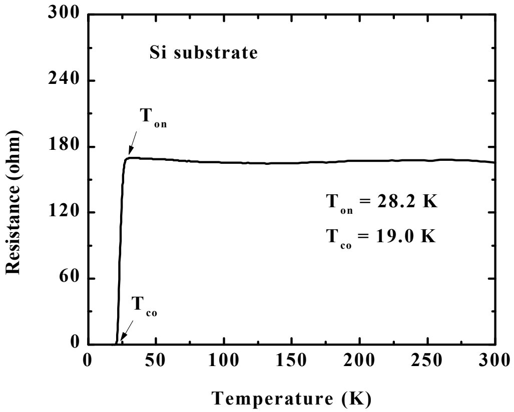
MgB2 far-IR detector development

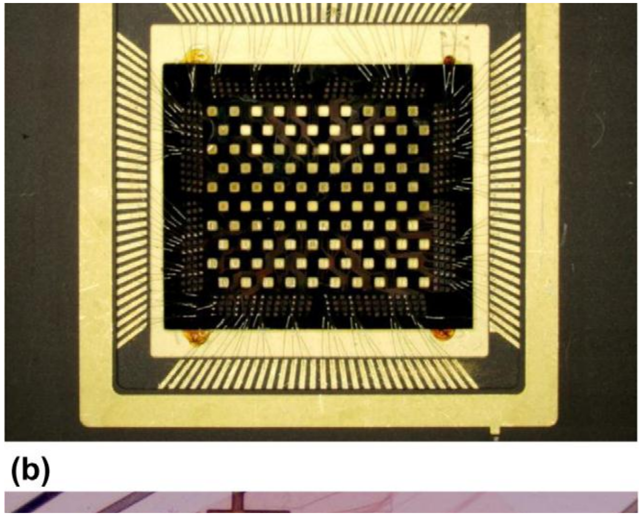
Our interest in MgB2:

- **Simple binary, intermetallic compound as opposed to YBCuO**
- **Superconducts near 38 K**
- **Grows on Si- SiN substrates and not exclusively on R-plane Al2O3 or LaAlO3. Easy to architecture (R and bias).**
- **Has the desirable properties for the development of sensitive high-Tc bolometers**
- **Recent positive advances in deposition techniques**
- **Quality polycrystalline MgB2 with Tc near 38K**

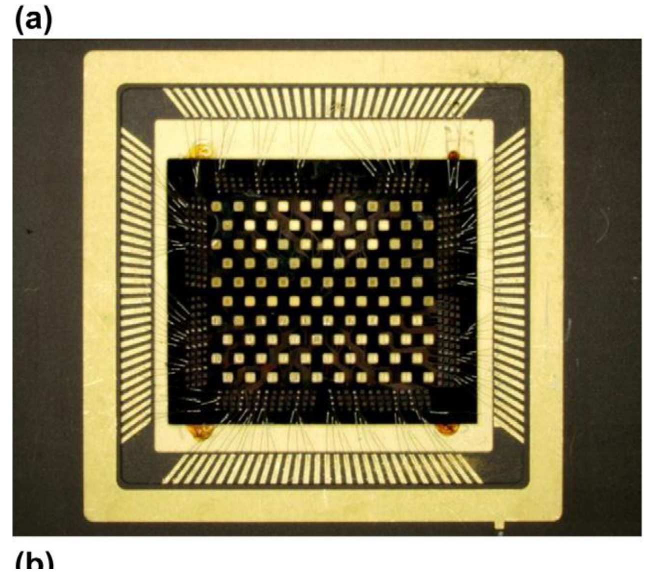


MgB2 on SiN pixel





Fabricated 10x10 MgB2 array (250 x 250 µm each)



Thin film MgB2 bolometer with resistive meander line (no absorber)

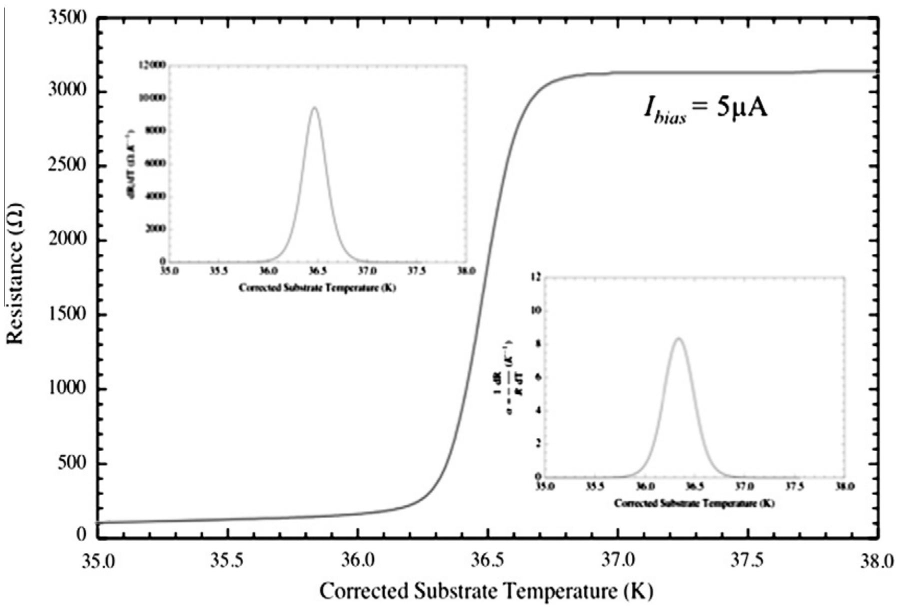
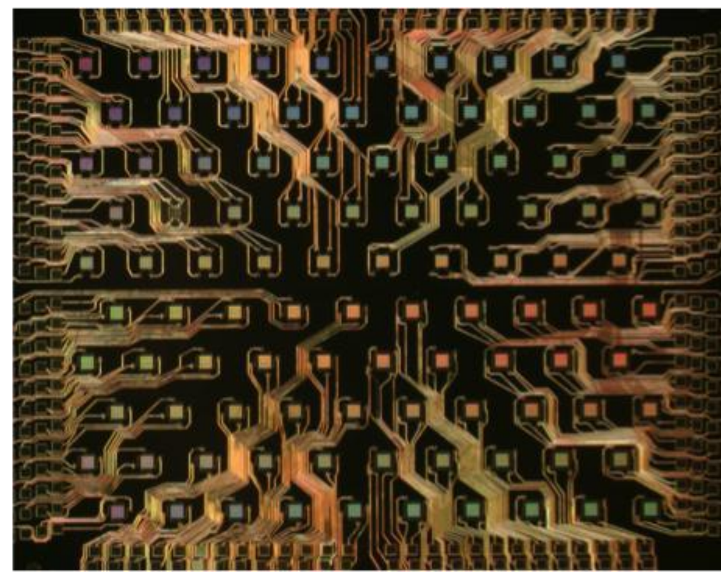


Fig. 3. *R*, *dR*/*dT* and α as a function of corrected substrate temperature.



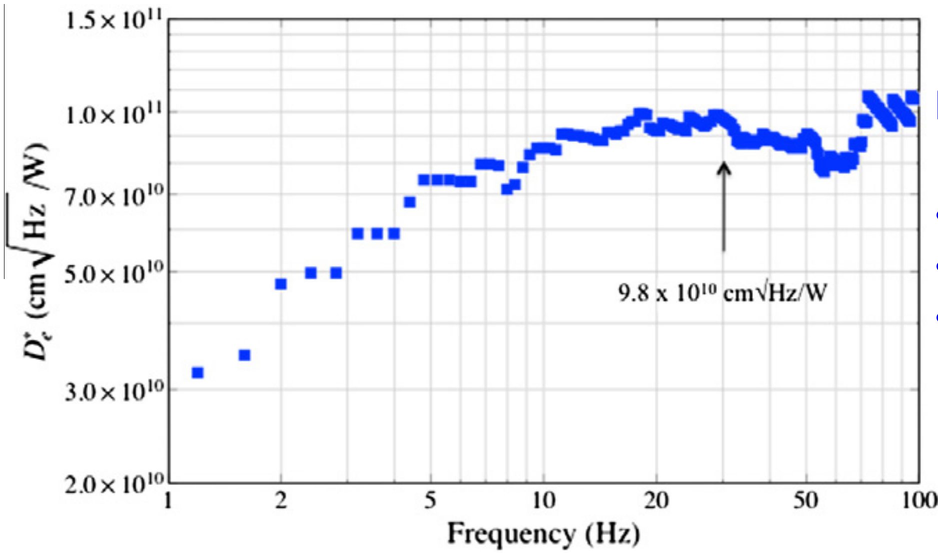


Fig. 7. Electrical detectivity, D_e^*, as a function of frequency.

MgB2:

- **Better sensitivity than thermopiles and YBCuO**
- **Better time constant**
- **Easier to produce single and 2-D arrays**

	Temp K	Optical Sensitivity D*
Thermopile	150-170	$3x10^9$
YBCuO	90	$1x10^{10}$
MgB2	38	$\sim 8.3x10^{10}$

More at:

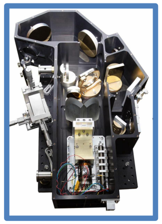
Physica C 483 (2012) 119–126

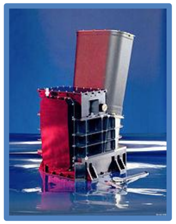
B. Lakew, S. Aslam *et al.*

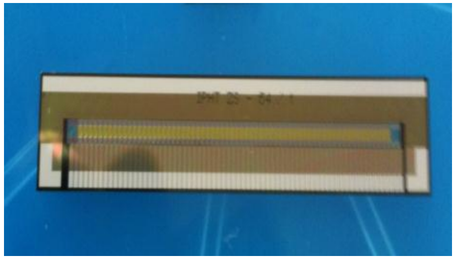
In conclusion:

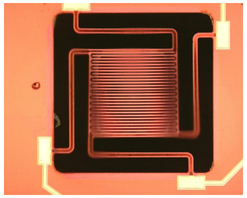
MgB2 is a better alternative to thermopiles and YBCuO
Easier to produce using MEMS processing

Challenge: Needs a cryocooler to operate at the transition.









TRL3 + cryocooler